INDOOR AIR QUALITY REASSESSMENT

Hanover Middle School
Hanover School District
45 Whiting Street
Hanover, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of Jeanmarie Joyce, Health Agent of the Hanover Board of Health, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA), provided assistance and consultation regarding indoor air quality concerns at the Hanover Middle School (HMS) in Hanover, Massachusetts. BEHA staff had conducted an indoor air quality assessment at the HMS during renovation of the building in February, 2000. Recommendations were made to ameliorate opportunities for exposure to building occupants as a result of pollutants generated by renovation efforts (MDPH, 2000a). A separate full indoor air quality assessment was issued March 2000 (MDPH, 2000b). The purpose of this reassessment was to identify whether indoor air quality had improved after renovations were completed.

On January 11, 2002 and March 1, 2002, the school was revisited by Michael Feeney, Director of BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) program, to conduct an indoor air quality reassessment. Mr. Feeney was accompanied by Ms. Joyce.

The school is a two-story brick building constructed in 1972 and renovated in 2000. The school contains general classrooms, media center, art room, cafeteria, science classrooms and administration office. Windows in the school are openable. The office and media center are carpeted. The floor of the remainder of the building is covered with tile.

During the course of the January 11, 2002 visit, the library was under remediation for water damage from a coil that had burst in the rooftop air-handling unit (AHU) above this area. A letter denoting BEHA recommendations concerning remediation was provided to the Hanover Board of Health and is included as Appendix I of this reassessment (MDPH, 2002).

Actions on Recommendations Previously Made by MDPH

As mentioned, BEHA staff had previously visited the school in February 2000 and issued a report that made recommendations to improve indoor air quality in various sections of the school (MDPH, 2000b). A summary of actions taken on previous recommendations is included as Appendix II of this reassessment.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor Model 8551.

Results

This school has a student population of over 630 and a staff of approximately 60. Tests were taken during normal operations at the school and results appear in the Tables 1-14.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million parts of air (ppm) in approximately 46% (29/63) of areas surveyed on January 11 and in 36% (5/14) on March 1, indicating a ventilation problem in a number of areas of the school. These carbon dioxide results are a marked improvement compared to the initial air monitoring conducted February 4, 2000, when thirty-three of thirty-eight areas (~87%) surveyed had carbon dioxide levels that were above 800 ppm during renovations. A comparison of test results is included in Tables 10-14. It is also important to note that some classrooms had open windows during the reassessment or were sparsely populated, which can greatly contribute to reduced carbon dioxide levels. These levels seem to indicate that the efficiency of the ventilation system needs to be improved to provide more fresh air for classrooms and offices.

Two different types of heating, ventilating, and air-conditioning (HVAC) systems supply fresh air to classrooms. Classrooms on exterior walls have fresh air supplied by a unit ventilator (univent) system. Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit. The mixture of fresh and return air is drawn through a filter and heating coil, and is then provided to classrooms from the univent by motorized fans through fresh air diffusers on the top of each unit (see Figure 1). Univents were deactivated in several classrooms. Obstructions to airflow, such as books and paper blocking univents, were seen in several classrooms. In order for univents to provide fresh air as designed, fresh air diffusers and univent returns must be unblocked and remain free of obstructions. Exhaust ventilation in exterior classrooms is provided by a mechanical system consisting of ducted, wall-mounted vents. This system was operating throughout the building.

The HVAC system in the central core areas consists of rooftop mounted AHUs. Air is distributed by ceiling-mounted air diffusers. Exhaust ventilation is provided by a combination of wall and ceiling-mounted return vents ducted back to the rooftop AHUs. Both supply and return vents were operating during the assessment.

The central core AHUs provide air-conditioning during warm weather. Exterior classrooms with univents do not have air conditioning capacity. The central core AHUs are located in the center of the Unit B building roof. In close proximity to the fresh air intake is a pair of large exhaust vents. Under certain wind and weather conditions it is possible that exhaust air from these vents can be entrained by the AHU and distributed into the central core of the building.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last servicing and balancing was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (BOCA, 1993; SBBRS, 1997). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this occurs, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please refer to Appendix III of this report.

Temperature readings recorded during the reassessment were in a range of 69 ^{o} F to 75 ^{o} F on January 11, 2002 and 69 ^{o} F to 74 ^{o} F on March 1, 2002, which were very close to BEHA's recommended comfort range. The BEHA recommends that indoor air temperatures be maintained in a range of 70 ^{o} F to 78 ^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

Relative humidity measurements ranged from 16 to 36 percent on January 11, 2002 and 16 to 22 percent on March 1, 2002, which were below BEHA comfort guidelines on both days. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Moisture/Microbial Concerns

Several classrooms had a number of plants. In some classrooms, flowering plants were observed on univent air diffusers. Several classrooms contained plants in window planters without drip pans. Window planters are designed to be mounted on the outside of windows and therefore do not have drip pans. The lack of drip pans can lead to water pooling and mold growth on windowsills when used indoors. Moistened plant soil, drip pans and standing water can serve as a source of mold growth. Plants should be equipped with drip pans and over watering should be avoided. In addition, plants should be located away from univents to prevent aerosolization of dirt, pollen or mold.

Classroom 209 contained a water-damaged sink cabinet. Improper drainage or sink overflow could lead to water penetration of countertop wood and potential damage to the cabinet interior as well as to materials stored therein. Water damaged ceiling tiles were noted in some areas near the library. Water-damaged wood, ceiling tiles, and standing water may also be a potential source of mold growth.

A water cooler was located directly on carpeting (see Tables). Porous materials that are repeatedly wet can serve as media for mold growth. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If porous materials, such as wallboard and carpeting are not dried within this time frame, mold growth may occur. Water-damaged carpeting cannot be adequately cleaned to remove mold growth.

Other Concerns

An insecticide, labeled “Fly Jinx”, was found on a table in room J-6 (see Picture 1). The product contains methoxyclor (organo-chlorine insecticide) which is a restricted use pesticide under state and federal law. Only individuals with a restricted pesticide applicator license can apply this product. Insecticides contain chemicals that can be irritating to the eyes, nose and throat. Under current Massachusetts law effective November 1, 2001, the principles of integrated pest management (IPM) must be used to remove pests in schools (Mass Act, 2000). In addition, applicators of pesticides should be in full compliance with federal and state rules and regulations that govern pesticide use, including posting and notification requirements (333 CMR 13.10). Under no circumstances should pest-controlling products be applied by untrained personnel. Such products should not be applied prior to or during school hours. A copy of the IPM guide is attached as Appendix IV.

The floor and walls of the art room were stained with clay dust and residue. The most notable stains were located around pottery wheels. Water and wet clay spinning off the wheel had coated the floor. Clay dust can be an eye, nose and throat irritant.

Classrooms contained dry erase boards with dry erase board markers or chalkboards. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999). Some rooms were noted to have excessive chalk dust. Chalk dust and dry erase board markers and cleaners can be irritating to the eyes, nose and throat.

The home arts room (224) was equipped with a washing machine and dryer. The dryer had been removed, leaving the vent pipe for this equipment open (see Picture 2). This vent can serve as a pathway for outdoor air, moisture and accumulated lint to migrate back into the classroom. Moistened lint can also be a growth medium for mold.

Classroom 26 has paper taped over the wall-mounted radiant heater (see Picture 3). This can also serve as a potential fire hazard.

The gymnasium has an unused water bubbler (see Picture 4). It appeared that no water had been poured into these drains recently. Without draining water, the drain traps can dry, resulting in the loss of the airtight seal created by a wet trap. A dry trap can result in sewer gas backing up into the building under certain circumstances. Sewer gas can be irritating to the eyes, nose and throat. The science classrooms have floor mounted emergency eye wash stations (see

Picture 5). The drainpipe in the base of the station appears to be open to the classroom and when activated, water is allowed to pour from the drain onto the floor. It could not be determined whether these units are connected to the plumbing system. If these eye wash stations are connected to the drainage system, it is also possible for sewer gas to migrate into classrooms through these openings.

Some classrooms contained a number of empty soda cans. Improperly stored food and beverage containers can serve as a source of mold and mildew growth as well as a food source for pests.

A number of areas had ceiling tiles that were either missing or ajar as a result of the AHU coil break. The ceiling plenum is an unconditioned space, which can have a different temperature than the occupied space. This differentiation in temperature can create air movement, which can capture particulate matter in the air stream and distribute this material into occupied areas through open sections of the suspended ceiling system. Particulate matter can be irritating to the eyes, nose and respiratory system.

In an effort to reduce noise from sliding chairs, tennis balls are sliced open and placed on chair legs (see Picture 6). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and off-gassing VOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix V (NIOSH, 1998).

Finally, photocopiers had been moved to room 218C. This area was not equipped with local exhaust ventilation to help remove excess heat and odors. In an effort to provide exhaust ventilation, a free standing floor fan is placed near open windows (see Picture 7). VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992).

Conclusions/Recommendations

In view of the findings at the time of this reassessment, the following recommendations are made:

1. Examine each univent for function. Survey classrooms for univent function to ensure adequate fresh air supplies exist for each room. Operate univents while classrooms are occupied. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers school-wide. If univents dampers cannot be readily adjusted, consider using windows to supplement fresh air in classrooms.
2. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
3. Once both the fresh air supply and the exhaust ventilation are functioning, the ventilation system should be balanced by an HVAC engineer.
4. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when relative humidity is low. Implement a dust control procedure. Institute wet mopping and wet wiping of horizontal surfaces (sweeping and dusting can stir up fine particulates).

Consider using a vacuum cleaner equipped with a high efficiency particulate efficiency (HEPA) filter to reduce the aerosolization of respirable dusts. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

5. Remove the pesticide container from classroom J-6. It is highly recommended that the principles of integrated pest management (IPM) be used to rid this building of pests. A copy of the IPM recommendations are included with this report as Appendix IV (MDFA, 1996).
6. Wet mop the floor in pottery wheel room immediately after use to control clay dust accumulation.
7. Have a chemical inventory done in all storage areas and classrooms. Discard hazardous materials or empty containers of hazardous materials in a manner consistent with environmental statutes and regulations. Follow proper procedures for storing and securing hazardous materials. Obtain Material Safety Data Sheets (MSDS') for chemicals from manufacturers or suppliers.
8. Maintain MSDS' and train individuals in the science department in the proper use, storage and protective measures for each material in a manner consistent with the Massachusetts Right-To-Know Law, M.G.L. c. 111F (M.G.L., 1983).
9. Move plants away from univents in classrooms. Examine drip pans for mold growth and disinfect with an appropriate antimicrobial where necessary. Consider reducing the number of plants in certain areas. Discontinue the use of window planters inside the building.
10. Remove paper from heater in room 26.

11. Seal openings in suspended ceiling to prevent dust and odor penetration into occupied areas.
12. Seal the dryer vent in classroom 224.
13. Run water into the drain of the unused water bubbler in the gymnasium to prevent drying of drain traps. If these sinks are not to be used, seal drains and disconnect water supply.
14. Clean chalkboards and chalk trays regularly to prevent the build-up of excessive chalk dust.
15. Place a plastic/rubber mat beneath the water cooler to prevent water damage to carpeting.
16. Determine whether eye wash units are connected to the plumbing drain system. If connected, seal pipe opening and pour water into pipe to maintain trap seal.
17. Discontinue the use of tennis balls on chairs to prevent latex dust generation.
18. Consider installing local exhaust ventilation in room 218C to vent photocopiers.

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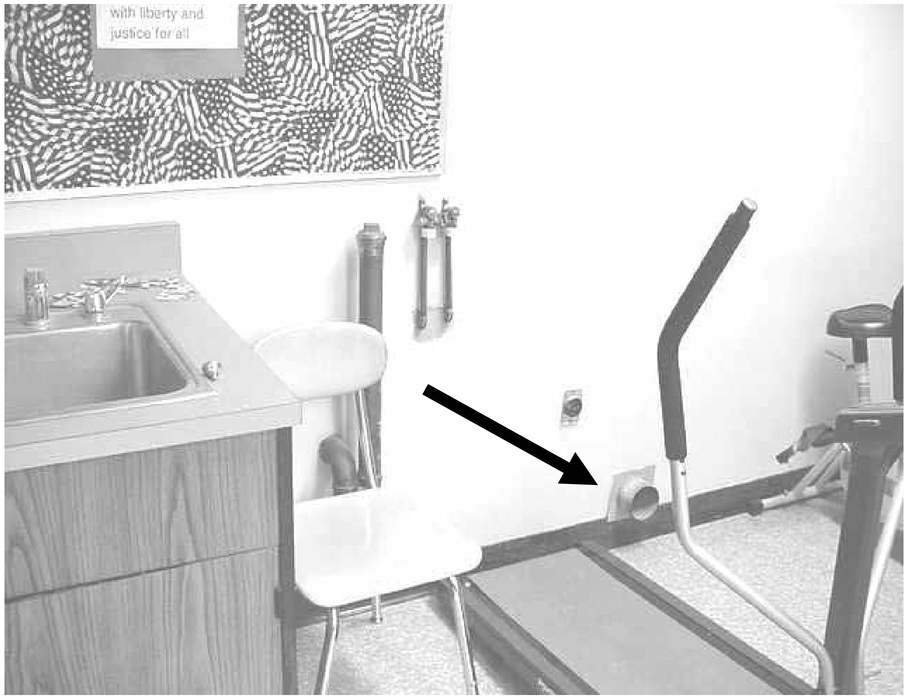
Picture 1

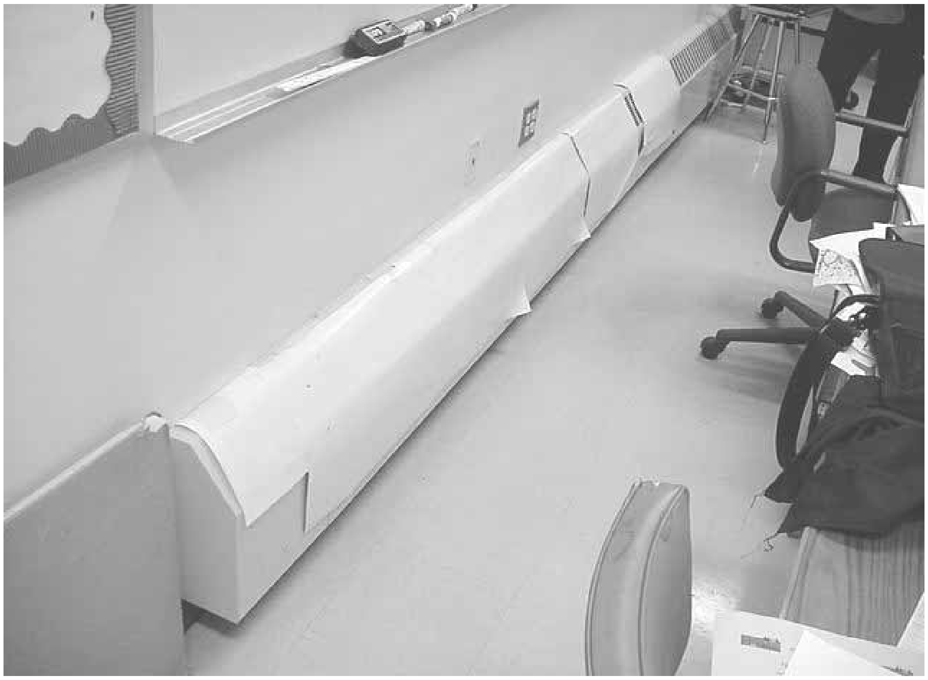
Pesticide in Classroom J-6

Picture 2



Open Dryer Vent in Room 224

Picture 3



Paper Taped over Radiator

Picture 4

Unused Bubbler in Gymnasium

Picture 5

Hole In Eyewash Station Drain

Picture 6

Tennis Balls On Chairs

Picture 7

Fan Used To Provide Exhaust Ventilation for Photocopiers

TABLE 1

Indoor Air Test Results – Hanover Middle School, Hanover, MA – January 11, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	386	35	48					
Nurse's Office	713	75	29	3	No	Yes	Yes	Door open
26	685	71	28	26	Yes	Yes	Yes	Dry erase board, paper over heater, door open
210 – Exterior	1056	73	32	25	Yes	Yes	Yes	4 door vents-no exhaust vent within room, plant, dry erase board, HEPA filter
207-Interior	552	73	29	9	No	Yes	Yes	
212-Exterior	626	74	30	15	Yes	Yes	Yes	
209-Interior (workroom)	444	72	30	1	Yes	Yes	Yes	Soda cans, water cooler on carpet, water damaged sink
211	430	70	30	1	No	Yes	Yes	Dry erase board, door open
J-6							Yes	Passive door vent (intake), Fly Jinx-methoxychlor
214-Exterior	956	74	32	24	Yes	Yes		

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems
Temperature - 70 - 78 °F
Relative Humidity - 40 - 60%

TABLE 2

Indoor Air Test Results – Hanover Middle School, Hanover, MA – January 11, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
215	676	72	31	24	No	Yes	Yes	Dry erase board, door open
Cafeteria	657	70	32	30	Yes	Yes	Yes	Door open
Guidance	456	70	31	2	Yes	Yes	Yes	Photocopier
Faculty Room	581	69	32	6	No	Yes	Yes	Door open
Library	441	71	31	3	No	Yes	Yes	Door open
124	766	71	33	24	Yes	Yes	Yes	Window open
122	959	71	34	12	Yes	Yes	Yes	Tennis balls, door open
119-Interior	424	72	31	1	No	Yes	Yes	1 missing CT
120	1097	73	35	23	Yes	Yes	Yes	Exhaust off, supply obstructed by book, plants, door open
118	1045	72	34	20	Yes	Yes	Yes	Table obstructing supply, soda cans, door open
116	1024	71	33	23	Yes	Yes	Yes	

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Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results – Hanover Middle School, Hanover, MA – January 11, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
114	1089	71	34	15	Yes	Yes	Yes	
216-Exterior	1085	74	33	1	Yes	Yes	Yes	Dry erase board
217-Interior	624	73	30	25	No	Yes	Yes	Ammonia-based cleaner, water damage, door open
218A-Exterior	1031	73	32	19	Yes	Yes	Yes	Door open
218B-Exterior	1071	73	32	18	Yes	Yes	Yes	Door open
218C-Exterior	616	73	30	0	Yes	Yes	Yes	4 photocopiers, door open
220	724	71	34	6	Yes	Yes	Yes	Plant on univent, door open
219	423	70	31	0	Yes	Yes	Yes	
222	612	73	32	3	Yes	Yes	Yes	
224	669	73	32	2	Yes	Yes	Yes	Exhaust off, open dryer vent, soda cans
201	573	73	31	24	No	Yes	Yes	4 water-damaged CT, door open

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	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 4

Indoor Air Test Results – Hanover Middle School, Hanover, MA – January 11, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
Technology	945	73	33	3	Yes	No	No	4 water-damaged CT
25	753	73	31	28	Yes	Yes	Yes	Floor drain, open pipe in eyewash
22	1032	72	32	28	Yes	Yes	Yes	Window and door open
21	798	72	32	18	Yes	Yes	Yes	Plant on univent, open pipe in eyewash, door open
20	1274	73	34	19	Yes	Yes	Yes	Door open
206	931	74	33	17	Yes	Yes	Yes	Door open
204	1233	74	33	28	Yes	Yes	Yes	Door open
Technology Classroom	879	73	33	20	Yes	Yes	Yes	Univent off, door open
A-2 Art Room	751	73	31	24	Yes	Yes	Yes	Plant on univent
A-1 Art Room	997	73	34	18	Yes	Yes	Yes	
Music 3	724	69	33	3	Yes	Yes	Yes	

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Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 5

Indoor Air Test Results – Hanover Middle School, Hanover, MA – January 11, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Music 2	1181	71	35	30+	Yes	Yes	Yes	
112	1185	72	34	23	Yes	Yes	Yes	Door open
110	1304	72	36	25	Yes	Yes	Yes	Univent off, door open, plants
109	514	72	31	3	No			
108	651	70	31	21	Yes	Yes	Yes	Window and door open, plants
106	1161	71	35	22	Yes	Yes		Passive vent-exhaust, door open
105	722	74	33	31	No	Yes	Yes	26 computers
103	636	74	31	18	No	Yes	Yes	
11	1045	72	32	19	Yes	Yes	Yes	Plants on univent, open pipe, dry erase board
15	825	72	31	19	Yes	Yes	Yes	Open pipe
16	1005	72	33	20	Yes	Yes	Yes	Door open

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Comfort Guidelines

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	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 6

Indoor Air Test Results – Hanover Middle School, Hanover, MA – January 11, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
14	1088	72	33	18	Yes	Yes	Yes	
12	905	72	32	17	Yes	Yes	Yes	
203	561	72	31	0	No	Yes	Yes	
120	977	71	22	25	Yes	Yes	Yes	Univent obstructed by boxes, accumulated items, tennis balls, door open
Technology Y	1114	71	22	23	Yes	Yes	Yes	22 computers
201	635	70	19	22	Yes	Yes	Yes	Door open
203	576	70	18	21				
208	616	72	19	0	Yes	Yes	Yes	Supply and exhaust blocked by boards
26	1012	73	21	0	Yes	Yes	Yes	Univent blocked by box
224	704	74	19	0	No	Yes	Yes	Soda cans, door open

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CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems
Temperature - 70 - 78 °F
Relative Humidity - 40 - 60%

TABLE 7

Indoor Air Test Results – Hanover Middle School, Hanover, MA – January 11, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
202	453	73	16	1	Yes	Yes	Yes	Window and door open, dry erase board

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CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 8

Indoor Air Test Results – Hanover Middle School, Hanover, MA – March 1, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outdoors	416	46	25					SW wind, wood smoke odor
120	977	71	22	25	Yes	Yes	Yes	Univent obstructed by boxes, accumulated items, tennis balls, door open
Technology Y	1114	71	22	23	Yes	Yes	Yes	22 computers
224	704	74	19	0	No	Yes	Yes	Soda cans, door open
202	453	73	16	1	Yes	Yes	Yes	Window and door open, dry erase board
Library	423	71	19	1	Yes	Yes	Yes	Door open
102	536	70	19	6	Yes	Yes	Yes	Window and door open
104	660	71	21	21	Yes	Yes	Yes	Window open, chalk dust
10	948	71	22	20	Yes	Yes	Yes	Dry erase board, door open
Hallway 1st floor-new wing								1 water damaged CT

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 9

Indoor Air Test Results – Hanover Middle School, Hanover, MA – March 1, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
107	486	71	18	2	No	Yes	Yes	2 missing CT, photocopier
Gymnasium	579	69	19	50	No	Yes	Yes	Drain trap-bubbler
Exercise Room	582	69	20	0	No	Yes	Yes	Door open
110	891	70	22	12	Yes	Yes	Yes	Boxes blocked univent, door open, chalk dust
118	1016	71	22	24	Yes	Yes	Yes	Boxes blocking univent, accumulated dust on exhaust vent, tennis balls, door open

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 10

Carbon Dioxide Air Monitoring Results Comparing February 4, 2000 to Sampling on January 11, 2002 and March 1, 2002
Hanover Middle School, Hanover, MA

Remarks	Carbon Dioxide *ppm 2/4/00	Occupants in Room	Carbon Dioxide *ppm 1/11/02	Occupants in Room	Change after Renovations (+/-) *ppm	Comments
Outside (Background)			386			
205	992	24	-	-		
Health	762	2				
101	868	8	-	-		
111	753	1				
Listening Room	695	0	-	-		
Main Office	839	2				
216	1061	21	1085	1	+24	
218B	1010	23	1071	18	+61	

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 11

Carbon Dioxide Air Monitoring Results Comparing February 4, 2000 to Sampling on January 11, 2002 and March 1, 2002
Hanover Middle School, Hanover, MA

Remarks	Carbon Dioxide *ppm 2/4/00	Occupants in Room	Carbon Dioxide *ppm 1/11/02	Occupants in Room	Change after Renovations (+/-) *ppm	Comments
210	1168	0	1056	25	-112	
110	1180	18	1304	25	124	
208	1963	27	616	0	-1347	27 less occupants
218A	1187	27	1031	19	-156	
112	1022	28	1185	23	163	
116	839	25	1024	23	185	
122	1150	21	959	12	-191	
Teachers' Workroom	791	7	581	6	-210	
215	891	20	676	24	-215	

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 12

Carbon Dioxide Air Monitoring Results Comparing February 4, 2000 to Sampling on January 11, 2002 and March 1, 2002
Hanover Middle School, Hanover, MA

Remarks	Carbon Dioxide *ppm 2/4/00	Occupants in Room	Carbon Dioxide *ppm 1/11/02	Occupants in Room	Change after Renovations (+/-) *ppm	Comments
217	851	19	624	25	-227	
103	865	25	636	18	-229	
207	784	0	552	9	-232	
106	1366	19	1161	22	-205	
124	1045	25	766	24	-279	
105	751	25	722	31	-29	
222	909	19	612	3	-297	16 less students
Cafeteria	989	2	657	30	-332	
224	1019	0	669	2	-350	

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 13

Carbon Dioxide Air Monitoring Results Comparing February 4, 2000 to Sampling on January 11, 2002 and March 1, 2002
Hanover Middle School, Hanover, MA

Remarks	Carbon Dioxide *ppm 2/4/00	Occupants in Room	Carbon Dioxide *ppm 1/11/02	Occupants in Room	Change after Renovations (+/-) *ppm	Comments
201	974	24	573	24	-401	
203	981	0	576	21	-405	
219	829	30	423	0	-406	Air measurement conducted while empty
Library	872	56	441	3	-431	Library under water damage remediation at time of testing
109	957	17	514	3	-443	14 less occupants
214	1422	24	956	24	-466	
204	1765	0	1233	28	-532	
114	1030	26	1089	15	59	
102	1138	27	536 (3/1/02)	6	-602	

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems
Temperature - 70 - 78 °F
Relative Humidity - 40 - 60%

TABLE 14

Carbon Dioxide Air Monitoring Results Comparing February 4, 2000 to Sampling on January 11, 2002 and March 1, 2002
Hanover Middle School, Hanover, MA

Remarks	Carbon Dioxide *ppm 2/4/00	Occupants in Room	Carbon Dioxide *ppm 1/11/02	Occupants in Room	Change after Renovations (+/-) *ppm	Comments
206	1570	20	931	17	-639	
104	1312	28	660 (3/1/02)	21	-652	
202	1318	20	453 (3/1/02)	1	-865	19 less occupants
108	749	0	651	21	-98	

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%